

An Integrated Approach for Mapping and Spatial Analysis of Auto Theft and Theft From Auto Criminal Incidents

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OUTLINE

- ❖ Introduction
- ❖ Method's Flowchart
- ❖ Data Collection
- ❖ Visualization
- ❖ Exploration
- ❖ Modelling
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- ❖ Conclusions

INTRODUCTION

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AIM

to develop a systematic methodology for mapping and analyzing spatial distribution of criminal incidents at the intraurban (mezo) level in order to support crime prevention policies

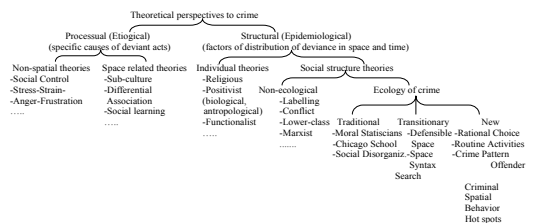
DEVELOPED METHODOLOGY

covers a GIS-based framework coupled with spatial data analysis tools of different softwares and consists of four systematic and complementary stages (step-vice)

CASE STUDY

includes implementation of the methodology to auto theft (AT) and theft from auto (TFA) incidents for the year 2000 in the City of Konya

Background to Methodology



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graph TD; A[Data collection (MapInfo)] --> B[Visualization (CrimeStat, MapInfo)]; B --> C[Exploration]; C --> D[Modelling]; D --> E[Assistance for spatial policy development process for criminal incident prevention]; C --> C1([Large scale effects (ArcGIS, CrimeStat, MapInfo, SPSS)]); C --> C2([Small scale effects (CrimeStat, M$Excel)]); D --> D1([Large scale effects (CrimeStat, MapInfo, M$Excel)]); D --> D2([Small scale effects (CrimeStat, M$Excel)]);
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The flowchart illustrates the methodology for criminal incident prevention, starting with **Data collection** (using MapInfo), followed by **Visualization** (using CrimeStat and MapInfo). The process then branches into **Exploration** and **Modelling**. Exploration involves **Large scale effects** (using ArcGIS, CrimeStat, MapInfo, SPSS) and **Small scale effects** (using CrimeStat, M\$Excel). Modelling involves **Large scale effects** (using CrimeStat, MapInfo, M\$Excel) and **Small scale effects** (using CrimeStat, M\$Excel). The final outcome is **Assistance for spatial policy development process for criminal incident prevention**.

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I. AT and TFA incidents as vector GIS data

Point objects obtained from the Security Directorate of Kenya in geocoded form for 2000

Incident number	Incident type	Incident Address
151	Travel Fraud	Frankfurt am Main, Germany
152	Travel Fraud	Frankfurt am Main, Germany
153	Travel Fraud	Frankfurt am Main, Germany
154	Travel Fraud	Frankfurt am Main, Germany
155	Travel Fraud	Frankfurt am Main, Germany
156	Travel Fraud	Frankfurt am Main, Germany
157	Travel Fraud	Frankfurt am Main, Germany
158	Travel Fraud	Frankfurt am Main, Germany
159	Travel Fraud	Frankfurt am Main, Germany
160	Travel Fraud	Frankfurt am Main, Germany
161	Travel Fraud	Frankfurt am Main, Germany
162	Travel Fraud	Frankfurt am Main, Germany
163	Travel Fraud	Frankfurt am Main, Germany
164	Travel Fraud	Frankfurt am Main, Germany
165	Travel Fraud	Frankfurt am Main, Germany
166	Travel Fraud	Frankfurt am Main, Germany
167	Travel Fraud	Frankfurt am Main, Germany
168	Travel Fraud	Frankfurt am Main, Germany
169	Travel Fraud	Frankfurt am Main, Germany
170	Travel Fraud	Frankfurt am Main, Germany

II. Background data

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• The neighborhoods and districts of Konya Metropolitan Area (study area)

• The existing landuse map obtained from the Plan Revision of Konya Metropolitan Area

Study Area:

Area: 371.5 km²

Perimeter: 141.9 km

II. Background data

2. Visualization

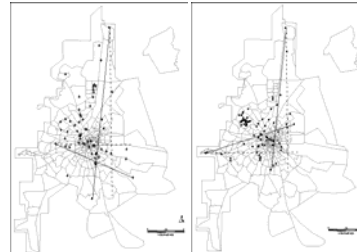
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- Simple display and mapping the data to get a general idea and better understanding about the distribution of the incidents
- Allows visual observation/interpretation of
 - up to where the incidents are distributed in space, i.e., extends of their distribution
 - spatial centrality and dispersion measures of the incidents
 - the interaction possibilities and trends that incidents have, i.e., whether they display clustering, regularity or randomness in space
- Consequently, gives idea about using which analytical tool is appropriate for further spatial exploration of the incidents

Visualization I. Simple measurements like extends

(MapInfo)



Horizontal-vertical extends of

AT incidents :
10.62 km - 23.98 km

TFA incidents :
12.92 km - 20.52 km

- AT & TFA display similar extends
- Yet, AT incidents are distributed in a narrower way in E-W and in a wider way in N-S direction than the TFA incidents

Visualization II. Spatial summary statistics

(CrimeStat, MapInfo)



- ATs & TFAs have similar centrality measures
- ATs are more dispersed and rectangular in shape
- TFAs are more concentric, square-like and clustered in distribution

Visualization III. Visual interpretations

(MapInfo)



- ATs are more dispersed,
- Both ATs & TFAs display clusters extending mainly in: N-S direction for ATs and NW-SE direction for TFAs.
- The incidents in the clusters of TFAs are observed to be located nearer to each other suggesting more spatial interaction among them

3. Exploration

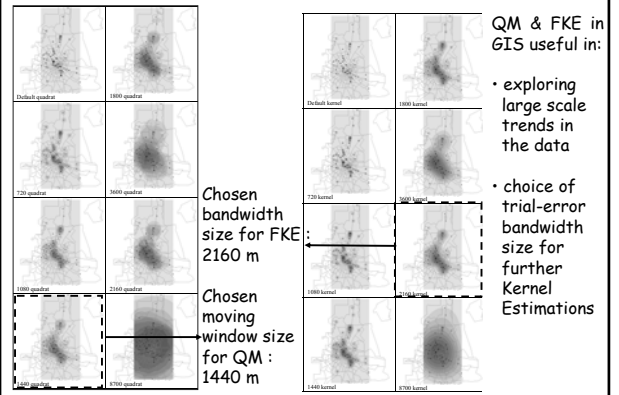
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- Performing simple quantitative manipulations on data for careful structuring of the visual interpretations
- Effects/components in behaviour of the spatial phenomena
 - Large scale (First order/Global): variation in the mean value
 - Quadrat Method
 - Kernel Estimation: Fixed, Adaptive, Dual
 - Hot-spot Analysis: NNNH Spatial & K-Means Clustering
 - Small scale (Second order/Local): result from spatial dependence or correlation (Bailey & Gatrell, 1995)
 - Nearest Neighbour Distance
 - K-Function
- Different methods are used in both exploring the large and the small scale effects
 - to complement each other
 - to overcome peculiar drawbacks of each method
 - to test if they provide results suggesting the same pattern of incidents
- The exploration results further need to be statistically tested in the modelling stage

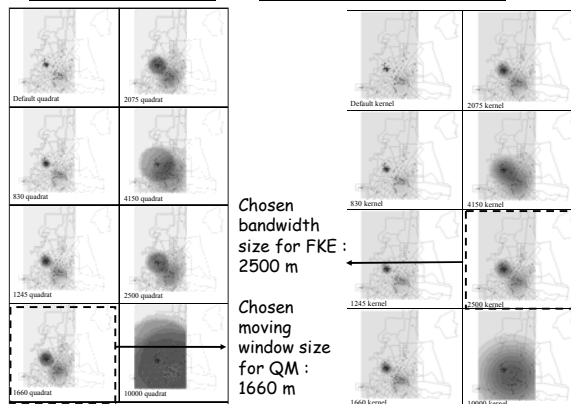
Exploration - Large Scale Effects I. (ArcGIS)

Quadrat Method (QM) and Fixed Kernel Estimation (FKE) for AT



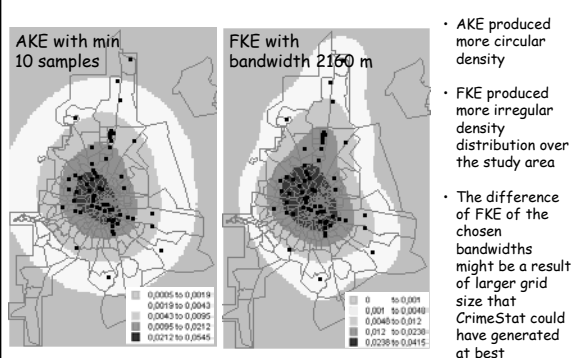
Exploration - Large Scale Effects I. (ArcGIS)

Quadrat Method (QM) and Fixed Kernel Estimation (FKE) for TFA



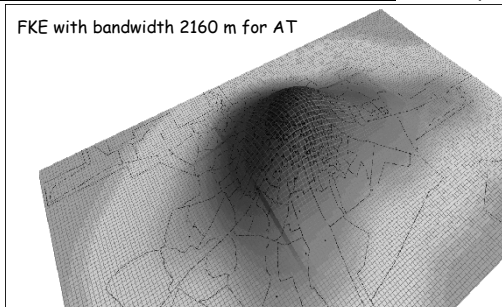
Exploration - Large Scale Effects II. (CrimeStat, MapInfo)

Fixed (FKE) and Adaptive Kernel Estimation (AKE) for AT (Example)



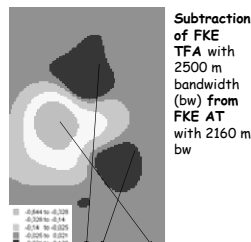
Exploration - Large Scale Effects III. *(CrimeStat, MapInfo)*
3D Visualization of Fixed Kernel Estimation (FKE) for AT (Example)

FKE with bandwidth 2160 m for AT



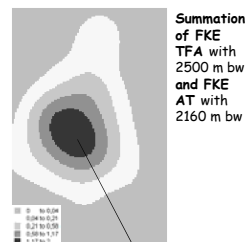
3D FKE surfaces give a better impression of the general/global trend or main hot-spot axes/areas for both data sets than they were simply observed in the visualization stage

Exploration - Large Scale Effects IV. *(CrimeStat, MapInfo)*
Dual Kernel Estimation (FKE) for AT & TFA



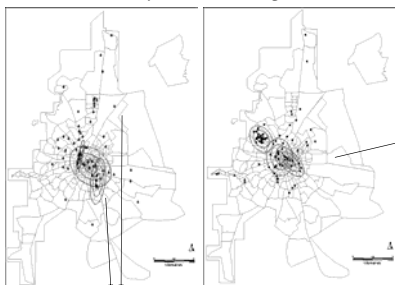
Northern and southeastern parts of the city where AT > TFA

In all the remaining parts of the city TFA > AT, but the difference becomes the largest in the centre



Areas towards the central parts of the city become more critical as far as the total densities of both type of incidents are concerned

Exploration - Large Scale Effects V. *(CrimeStat, MapInfo)*
Hot-spot Analysis through Nearest Neighbour Hierarchical Spatial Clustering for AT & TFA

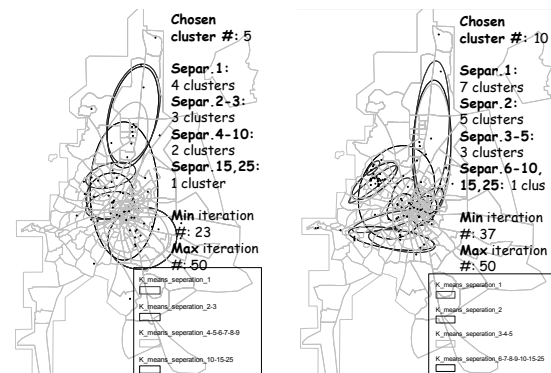


The ones that are visualized & explored in the same way for TFAs (extending in NW-SE direction) are validated to a larger degree

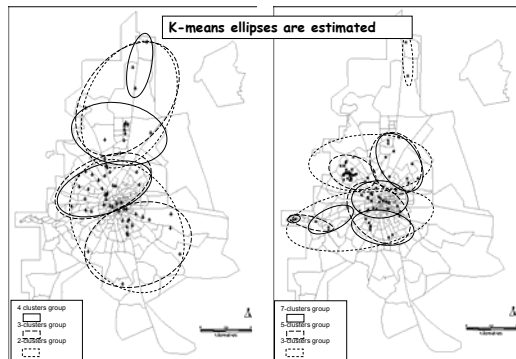
In both, there are no 2nd or 3rd order nested clusterings

The clusters found in visualization, quadrat and kernel explorations of ATs (extending in N-S direction) are validated to a certain degree

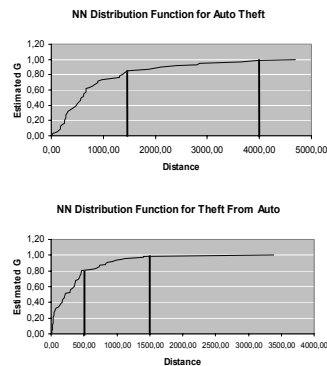
Exploration - Large Scale Effects VI. *(CrimeStat, MapInfo)*
Hot-spot Analysis through K-Means Clustering for AT & TFA



Exploration - Large Scale Effects VI. (SPSS, MapInfo)
Hot-spot Analysis through K-Means Clustering for AT & TFA



Exploration - Small Scale Effects I. (CrimeStat, MSEXcel)
Nearest Neighbour Distance (NND) for AT & TFA



- Steep climbs show inter-event/local interactions and clusterings in AT & TFA
- Yet, as in visualization the distances that they interact and the degrees of clustering are different

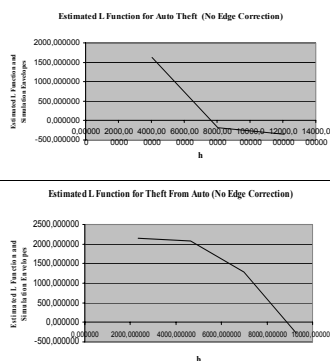
The interaction is maximized at about

AT incidents: 1500 m
 TFA incidents: 500 m

Inter-event interaction stops at about

AT incidents: 4000 m
 TFA incidents: 1500 m

Exploration - Small Scale Effects II. (CrimeStat, MSEXcel)
L-Function derived from K-Function for AT & TFA



- Proper interpretation of L function is not possible due to only 3 bins where
 - peaks would show clustering and,
 - troughs would show regularity (Bailey & Gatrell, 1995)
- Although K-function is more robust tool for small scale effects, here the NND method has been more useful

OUTLINE

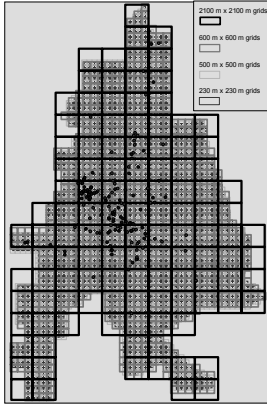
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4. Modelling

- The exploratory analyses are not sufficient to support the explicit tests of various hypotheses or to construct particular models to explain the observed pattern of events (Bailey & Gatrell, 1995)
- In modelling, evaluations are made via statistical tests of the hypotheses stating complete spatial randomness (CSR) constructed for the previously found results
- The standard model for the CSR is that events follow a homogenous Poisson process over the study area (Bailey & Gatrell, 1995)

Modelling I. Tests for Quadrat Method for AT & TFA

(CrimeStat, MapInfo, MSEXcel)



- Observed and expected points counts in cells are compared by chi-squared test (Anselin et al,2000) Ho: CSR
- Index of Dispersion (ID) or Variance Mean Ratio (VMR) and Index of Cluster Size (ICS) are calculated for different quadrat sizes
- Clusterings found previously are significant for all the grids
- Relative randomness of ATs is seen from the ranges

AT 3.13 \geq ID \geq 1.02; ID > 1 clustering
 AT 2.13 \geq ICS \geq 0.02; ICS > 0 clustering
 TFA 10.98 \geq ID \geq 1.45; ID > 1 clustering
 TFA 9.98 \geq ICS \geq 0.45; ICS > 0 clustering

Modelling II. Tests for NND Method for AT & TFA

(CrimeStat, MSEXcel)

➤ Clark-Evans Test

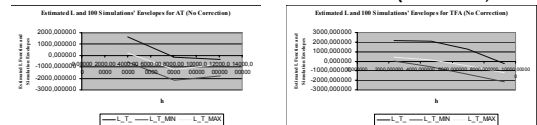
Ho: CSR is safely rejected at 0,00001 significance level for AT
 0,000000000003 significance level for TFA

➤ Nearest Neighbour Index (NNI)

NNI=0 perfect clustering
 NNI=1 perfect randomness
 NNI=2,1 perfect regularity
 NNI=0,901282 for AT (not significant at 0.05)
 NNI=0,481167 for TFA (significant at 0.0005)

Modelling III. Tests for K-Function Method for AT & TFA

(CrimeStat, MSEXcel)



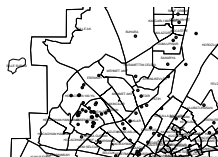
- Ho: CSR is rejected at all h distances for K-Function since the L-Function estimates lie outside the corresponding upper simulation (100 here) envelopes (Bailey & Gatrell,1995) for both AT & TFA

Discussions

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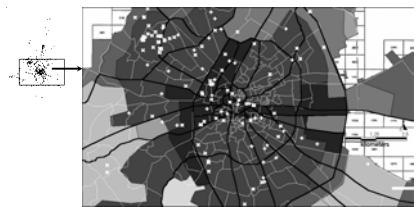
- Spatial distribution of both incidents are significantly clustered
- AT incidents display relatively more dispersed N-S directed pattern in global level and interactions at farther distances at in local level
- TFA incidents display relatively more clustered, condensed NW-SE pattern in global level and interactions at nearer distances in local level
- Investigations of these results with background information data including neighbourhoods and existing landuse map obtained from the Plan Revision of the Konya Metropolitan Area help to develop policies to prevent AT and TFA incidents in the City



Discussions (Cont.)

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As expected, majority of both incidents' hot-spots were found out to coincide with CBD which has diverse land-uses (mainly commercial/shopping, social, touristic, etc.) . The CBD and its near proximities become deserted after working hours because of less residential uses and hence, it is under less surveillance and social control particularly at nights.

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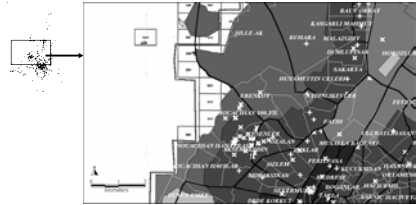


Another high-incident level area in the CBD, which is located within a near north-west proximity of the core Hamidiye neighbourhood and lies towards the south of Feritpaşa neighborhood is the old bus terminal area. This area is in a very deteriorating situation just like the transition zone defined and theorized by the Chicago School back in 1925.

Discussions (Cont.)

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A major clustering area for particularly TFAs, has been Hocacihan 100.Yıl and its two more southern neighbors, as opposed to "old CBD". These neighborhoods are mainly "new residential areas" where they are away from regular surveillance. As in the previous case the routine activities and defensible space theories may help to explain the incident densities in these areas.

Discussions (Cont.)

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The northern parts of the Selçuklu district, which start from Süleyman Çelebi and include Bosna Hersek, Yazır, and Sancak neighborhoods, are newly settled areas with relatively less population and they have relatively less incidents compared to their southwards old settlement counterparts.

Discussions (Cont.)

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The old northern parts of the city are in the near proximity of working and living areas of low-income level people, in which the small-scale industrial activity (shoe production, wool processing, etc.) of the city takes place. These neighborhoods are Horozluhan, Fevzi Çakmak, Fatih, HacıYusufMescit, Organize 1, and one more neighborhood in the east of Organize 1.

Conclusions

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- In this study, spatial data analysis tools of different softwares made for different purposes are systematically compiled and used in a GIS-based framework for criminal incidents
- The complementary four stages in the developed methodology for mapping and analyzing spatial distribution of criminal incidents at the intraurban (mezo) level can support in development of crime prevention policies at this level
- The flexibility of the developed methodology can be tested with different cases and afterwards, it can be revised
- The most important drawback of the study is that it requires a comprehensive knowledge of all the spatial data analytical tools and the softwares utilized
- The future studies may involve development of a software that includes all these GIS-based spatial data analysis framework peculiar to criminal incidents

Acknowledgement

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